EVALUATION OF IMPROVED SEPARATOR MATERIAL IN LARGE SILVER-ZIND CELLS FOR USE IN SUBMERSIBLE VEHICLES

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ENERGY RESEARCH CORPORATION

EVALUATION OF IMPROVED SEPARATOR MATERIAL IN LARGE SILVER-ZINC CELLS FOR USE IN SUBMERSIBLE VEHICLES

FINAL REPORT

1 Aug. 1972 to 31 Jan. 1974

Contract N00024-73-C-5044

by:

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ABSTRACT

Two NR-1 and 2 Dolphin silver-zinc cells were fabricated using inorganic separators supplied by NASA-Lewis. All cells contained KT paper on the negatives. One Dolphin cell contained KT manufactured by ERC.

Delays were encountered in the construction of these cells because of poor quality inorganic separators and delays in shipment of uniform materials.

Because of the geometry of the NR-1 cell and the great thickness of the inorganic separators compared to cellophane only 800Ah (nominal capacity) could be designed in the available volume. The Dolphin cell geometry provided a greater latitude for design flexibility and the 4000Ah requirement could be designed into the existing box.

The NR-1 cells were shipped to NAD Crane for testing and the Dolphin cells were shipped to Mare Island Naval Shipyard Valejo, California for testing. All cells were shipped in the dry uniformed condition.

1.0 INTRODUCTION

The purpose of this program was to fabricate prototype silver-zinc cells of NR-1 (850Ah) and Dolphin (4000Ah) sizes containing inorganic separators supplied by NASA-Lewis Research Center.

These separators had previously been developed under a NASA contract by the Astropower Division of McDonnel-Douglas Corp. for use in heat-sterilizable silver-zinc cells.

In all, 2 NR-1 and 2 Dolphin cells were built; the NR-1 cells were shipped to NAD-Crane for testing, and the Dolphin cells were shipped to Mare Island Naval Shipyard for testing.

The original six month program extended over 18 months due to rejection of separator materials and delays in receiving improved separators.

2.0 BODY OF THE REPORT

This final report under contract No. N00024-73-C-5044 covers the period of performance from 1 Aug. 1972 to 31 Jan. 1974 for the fabrication of large size silver-zinc cells containing improved separator materials.

2.1 Inorganic Separator Materials

The main separator materials used in both the NR-1 and Dolphin cells were supplied by NASA-Lewis Research Center.

The first lot of 700ft^2 of material received on 3 Sept. 1972 designated GFM separator. The material in the dry con-

dition varied from .016" to .019" and some areas appeared to be uncoated.

The material was subjected to resistivity testing by soaking samples in 42% KOH for 72 hours followed by measuring resistance with a General Radio impedance bridge. After a 72 hour soak period, the resistance was 120-125 milli-ohm-in^{-2} which was considered to be on the "high side". No change in thickness was noted during the soaking period.

In addition, 2 40Ah cells were fabricated with 2 layers of the GFM material and subjected to a rapid cycling regimen to determine the preliminary characteristics of the separator material.

The cells were cycled at a charge rate of 2A to 2.10volts and discharged at 10A to 1.25 volts. After 45 cycles one cell shorted and was dissected. It was found that zinc had penetrated the negative separator bag through to the positive plate. Zinc dendrites were noted in several areas through the separator material.

Based on these poor initial results, a meeting was held with Mr. A. Himy of Naval Ship Engineering Center and it was decided to reject this first lot of material and request a new batch of separator from NASA-Lewis.

Modification P00003 was issued on 2 Apr. 1973 to extend the delivery date of the cells to 30 June 1973. A second shipment of separator material was received in April 1973 and it was found to be partially unfit for use. A second

modification P0004 was issued on 22 June 1973 postponing the delivery of the cells to 31 Aug. 1973, with a provision for "in plant" storage of the cells until notified by NAVSEC of destination of shipment.

Inspection of the second lot of material showed that the first 5 yards were not coated. Thickness of the acceptable materials was .015"-.017" and resistivity measurements showed that the electrical resistance was lowered to .090-.095 milli-ohm-in^{-2}.

2.2 Potassium Titanate Paper Separator

The potassium titanate (KT) separator was purchased from Mead Technical papers and designated LPM-174-67. It is not pure KT but contains 20% Fiberfrax which is a hydrated aluminum oxide binder. The material had a thickness of .012" and did not expand when soaked with 42% KOH.

Three of the four cells fabricated contained the Mead KT paper. The last cell (Dolphin) contained KT separator fabricated by ERC. It contained KT and Teflon but did not contain Fiberfrax and was .010" thick in the finished state. Mead discontinued the manufacture of KT paper which necessitated the fabrication of our own material for the final Dolphin cell.

2.3 Design Features Common to NR-1 and Dolphin Cells

The positive plates were made of sintered silver powder at a density of 4.8g/cc on 5Ag5-4/0 expanded silver metal. The negative plates were made from a mix containing 95.5% ZnO, 2% HgO, and 2.5% Teflon. The density of the plate (as zinc metal) was 2.0g/cc and the ratio of theoretical Ah ZnO to theoretical Ah Ag was 1.3:1.0. The negative plates were made by pressing two rolled strips of ZnO mix onto either side of an upset silver (Distex) expanded metal followed by a layer of KT paper on each face.

The separator system consisted of one layer of GFM inorganic material (as a bag) on the positive and one layer of GFM inorganic separator (as a bag) on the KT/negative composite.

The separator bags were formed around the electrodes by joining two individual pieces of material on either side of a central ABS plastic "U" shaped border 3/1/6" in width. The ABS material was about .080" thick to accommodate the KT/negative composite and about .035" thick for the positive plate. It was found that an Epibond type epoxy formed an excellent bond between the ABS "U" frames and the inorganic separators. These bags were formed in place around the electrodes to minimize handling of the separator material.

2.4 Details of NR-1 Cell Design

The NR-1 cells contained 22 positives plates, 21 full negative plates and 2 half end plates. The dimensions of the electrodes were 12.25" in height, 4.00" in width and .033" thick for the positive plates and .058" for the full negative plates (.030" for the half plates).

The total weight of silver in each cell was 2800g and the total weight of zinc oxide was also 2800g. The nominal capacity based on a silver utilization of 3.5g/Ah was 800Ah.

Because of the relative bulkiness of the inorganic and KT separators the required capacity of 850Ah could not be designed into the existing volume.

The NR-1 cases were hand fabricated from 3/16" thick polysulfone material and the overall cell dimensions were somewhat larger than the specifications because of the thicker plastic material which was employed.

2.5 Details of Dolphin Cell Design

The Dolphin cells contained 48 positive plates, 47 full negative plates and 2 half end plates. The dimensions of the electrodes were 13.47"in height, 8.56" in width and .032" thick for the positives plates and .056" for the full negative plates (.029" for the half plates).

The total weight of silver in each cell was 14,000g and the total weight of zinc oxide was also 14,000g. The nominal

capacity based on a silver utilization of 3.5g/Ah was 4000Ah. Since the volume available in this cell was slightly greater than for the NR-1 cell (even taking into account room for cooling panels and firewalls) the capacity requirement could be met.

The cell cases, covers and terminal hardware used consisted of re-worked parts supplied by NAVSHIPS and were manufactured by Mead and Cell No. 2 contained KT separators made by ERC.

The cells met the spacial requirements and weighed 128lbs. in the dry condition.

3.0 SHIPMENT OF THE CELLS

3.1 NR-1 Cells

The NR-1 cells were shipped to NAD Crane, Indiana in the dry uniformed condition along with filling and formation proceedures.

3.2 Dolphin Cells

The Dolphin cells were shipped to Mare Island Naval Shipyard, Valejo, California, in the dry uniformed condition along with filling and formation proceedures.